

(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets



(11)

**EP 1 106 190 A1**

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:  
13.06.2001 Bulletin 2001/24

(51) Int Cl.7: **A61L 29/04**, C08L 25/08,  
C08L 23/02

(21) Application number: 00126419.1

(22) Date of filing: 05.12.2000

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE TR**  
Designated Extension States:  
**AL LT LV MK RO SI**

(30) Priority: 09.12.1999 JP 34979099

(71) Applicant: Nissho Corporation  
Osaka-shi, Osaka-fu, 531-8510 (JP)

(72) Inventors:  
• **Nizuka, Takeshi**  
Kita-ku, Osaka-shi, Osaka-fu 531-8510 (JP)  
• **Mitani, Hideki**  
Kita-ku, Osaka-shi, Osaka-fu 531-8510 (JP)  
• **Shimada, Mamoru**  
Kita-ku, Osaka-shi, Osaka-fu 531-8510 (JP)

(74) Representative: Albrecht, Thomas, Dr. et al  
Kraus & Weisert,  
Thomas-Wimmer-Ring 15  
80539 München (DE)

### (54) Medical tubing

(57) A medical tubing of a random copolymer containing an olefin-based monomer, such as ethylene, in an amount of 50-95 mol %, and preferably, 75-95 mol %, and a styrene-based monomer, such as of styrene in an amount of 50-5 mol %, preferably 25-5 mol %. The medical tubing can be used as a conjugating tube or a connecting tube of medical equipment such as infusion

circuits and blood circuits, and for administering an oil-soluble drug such as nitroglycerin. The random copolymer does not contain chlorine atoms or a plasticizer. The tubing has very small adsorption of the drugs, can withstand squeezing action by an infusion pump, has a possibility of undergoing  $\gamma$ -ray sterilization and has flexibility necessary for clinical use.

EP 1 106 190 A1

**Description**Field of the Invention

- 5 [0001] The present invention relates to a medical tubing, and especially relates to a medical tubing which can constitute a part of medical equipment such as infusion circuits, blood circuits, and the like.

Background of the Invention

- 10 [0002] Tubes formed mainly from a soft polyvinyl chloride (PVC) containing diethylhexylphthalate (DEHP) or the like as a plasticizer have been used for a long period of time as medical tubing and, more particularly, have been used as conjunction tubes or connecting tubes of medical equipment such as infusion circuits, blood circuits, and the like. However, PVC is a homopolymer of vinyl chloride which contains a chlorine atom. Therefore, when products formed from the polymer are incinerated, there is a possibility that a harmful substance, dioxin, is generated depending on the conditions of incineration. Further, there is a possibility that DEHP contained in PVC as a plasticizer is eluted into a drug liquid charged in PVC products or into blood passed through the PVC products, and be introduced in a human body. Furthermore, there is a problem that a drug such as nitroglycerin that is required to be accurately injected is adsorbed by the tubes and a desired amount of the drug is not administered.

- 15 [0003] It is supposed that harmful dioxins are not generated when a PVC product is incinerated at a high temperature. A general small-sized incinerator is not satisfactory for such incineration because the incinerator cannot provide a high temperature. A large-sized incinerator to meet this requirement is desired but a high cost is required to install such an incinerator.

- 20 [0004] Further, DEHP contained in PVC products as a plasticizer is a low molecular weight compound and it is expected that it is easily eluted from PVC products and introduced into a human body. In particular, when a drug containing ethanol or polyethylene glycol as a dissolving agent or blood is contained in a bag formed from PVC containing DEHP, or is passed through a tube formed from the polymer, its elution is remarkable. For this reason, PVC products not containing a plasticizer have been investigated. One example thereof is a PVC product obtained by copolymerization with an ethylene-vinyl acetate copolymer according to a specific method. However, this PVC product also contains chlorine atoms and its cost is very high. Thus, such a product can not generally be used. Further, in the case of a drug such as nitroglycerin that requires a precise injection being contained in the bag, the problem of drug adsorption has not yet been solved.

- 25 [0005] In view of the above, an infusion tube formed from a very low density polyethylene having a density of 0.89 g/cm<sup>3</sup> or less has been proposed as a medical tubing for intravenous injection of nitroglycerin (Japanese Patent Examined Publication No. Hei 1-48775). This tube adsorbs a very small amount of nitroglycerin, and therefore an intended amount of the drug can be administered. However, there is a physical problem that although the tube has sufficient flexibility for use as a medical tubing, the tube does not withstand squeezing by an infusion pump when an accurate flow rate is required.

- 30 [0006] The drug adsorption property of an infusion tube formed from polyvinyl chloride or polybutadiene has been discussed (M. Gerard Lee, American Journal of Hospital Pharmacy, Vol. 43, Aug. p.1945-1950, 1986). A tube made of polybutadiene also has a very small adsorption property with respect to a drug such as nitroglycerin, and therefore is suitable for administration of such a drug. However, since a double bond still remains in a polymer chain, storage conditions or processing conditions are restricted, or a stabilizer must be used, in order to prevent a change in the physical properties of the tube during storage for a long period of time, or to prevent gelation during molding and processing of the tube. Thus, such a tube does not always satisfy safety requirements when used as a medical tube.

- 35 [0007] Further, to sterilize a tube made of 1,2-polybutadiene with  $\gamma$ -ray radiation, it is necessary to add a phosphorus-based antioxidant (Japanese Patent Unexamined Publication No. Hei 5-98075). Such a composition is not preferable as a medical tubing from this standpoint. Also, there is a problem that this medical tubing does not withstand squeezing by an infusion pump.

- 40 [0008] Furthermore, a resin composition comprising polybutadiene and a styrene-isoprene-styrene block copolymer is proposed as a composition suitable for medical products such as medical tubing, soft catheters, sheets and the like (Japanese Patent Unexamined Publication No. Hei 6-184360). This resin composition has very excellent flexibility, and therefore is put into practical use as an infusion tube for a pump. However, because it cannot withstand deterioration of portions squeezed by the pump, a silicone resin is coated on its surface. Moreover, because a styrene-isoprene-styrene block copolymer is unstable, there is a problem that the tube turns yellow during storage for a long period of time or in  $\gamma$ -ray sterilization.

- 45 [0009] Also, a drug administration tube comprising a blend of polyethylene and a styrene-based elastomer or olefin-based elastomer has been proposed (Japanese Patent Examined Publication No. Hei 2-31990). Since drug adsorption is small by this tube, the intended amount of drug can be administered. However, because an elastomer is added to

polyethylene, rigidity of a molded tube decreases and there is a problem that the tube does not withstand the squeezing action of a pump.

[0010] In view of the above situation, the present inventors variously investigated medical tubing formed of a material not containing a chloride atom or a plasticizer for the purpose of obtaining the medical tubing having low drug adsorption, resistance to squeezing by a pump, a possibility of undergoing  $\gamma$ -ray sterilization, and a flexibility necessary for clinical usage. The inventors found that a random copolymer of an  $\alpha$ -olefin-based monomer and a styrene-based monomer achieves the expected purpose of the present invention.

#### Brief Description of the Drawing

[0011] Fig. 1 is a view showing one embodiment of the use of the medical tubing of the present invention.

#### Summary of the Invention

[0012] The present invention relates to a medical tubing containing a random copolymer comprising an olefin-based monomer and a styrene-based monomer.

[0013] The olefin-based monomer useful in the present invention, includes  $\alpha$ -olefins. The  $\alpha$ -olefins are  $\alpha$ -olefin monomers having 2-20 carbon atoms, and include, specifically, ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 4-methyl-1-pentene, 2-methyl-1-propene, 3-methyl-1-pentene, 5-methyl-1-hexene, and the like.

[0014] In the present invention, the styrene-based monomer includes styrene, p-methylstyrene, t-butylstyrene, vinyl pyridine and  $\alpha$ -methylstyrene.

[0015] The random copolymer comprising an olefin-based monomer and a styrene-based monomer useful in the present invention specifically includes a random copolymer comprising ethylene and styrene and a random copolymer comprising propylene and styrene.

[0016] In the present invention, the random copolymer comprising an olefin-based monomer and a styrene-based monomer can be a random copolymer copolymerized with another monomer such as a monomer containing a glycidyl group, amino group, dimethylamino group, hydroxyl group, carboxyl group, ester group, ether group or isocyanate group, or a maleic anhydride. The copolymerization proportion thereof is within a range that achieves the purpose of the present invention.

[0017] The copolymerization ratio of the random copolymer of the present invention is preferably one where the olefin-based monomer is 50-95 mol% and the styrene-based monomer is 50-5 mol%. More preferably, the olefin-based monomer is 75-95 mole and the styrene-based monomer is 25-5 mol%, and most preferably, the olefin-based monomer is 80-90 mol% and the styrene-based monomer is 20-10 mol%. If the styrene-based monomer is less than 5 mol%, hardness of the tube is increased and transparency thereof is reduced. Further, if it exceeds 50 mol%, the elasticity necessary for a medical tubing cannot be obtained.

[0018] A specific example of the present invention is a medical tubing containing a random copolymer of ethylene and styrene. The random copolymer of ethylene and styrene is preferably one in which the ethylene content is 75-95 mol% and the styrene content is 25-5 mol%. Further, it is particularly preferable that the ethylene content is 80-90 mol% and the styrene content is 20-10 mol%.

[0019] The ethylene-styrene random copolymer used in the present invention is a random copolymer of ethylene and styrene and optionally, contains another olefin monomer if necessary.

[0020] The random copolymer means a copolymer in which a proportion of a block or blocks comprising two or more continuous units derived from the  $\alpha$ -olefin based monomer or styrene based monomer is 10% or less, and preferably, 1% or less with respect to the amount of a copolymer derived from both monomers. The content of a block or blocks consisting of two or more continuous units derived from the styrene-based monomer may be determined by  $^{13}\text{C}$ -NMR.

[0021] Styrene-ethylene-butylene-styrene block copolymer (SEBS), styrene-isoprene-styrene block copolymer (SIS), styrenebutadiene-styrene block copolymer (SBS) and the like have conventionally been known as a copolymer of an olefin such as ethylene with a vinyl aromatic compound such as styrene. These copolymers have styrene block portions and the olefin block portions, respectively. On the contrary, the ethylene-styrene random copolymer of the present invention is one in which ethylene and styrene are randomly copolymerized as mentioned above, and a low styrene content region does not have a block portion of styrene in the structure of the copolymer. As a result, this random copolymer substantially differs from the above-mentioned styrene-based elastomer such as SEBS.

[0022] The melt flow ratio (200°C, MFR) of the random copolymer of the present invention is 0.01-100 g/10mins, preferably, 0.1-50 g/10mins, and more preferably, 0.3-10 g/10mins. The melting point is 100°C or lower.

[0023] The random copolymer of an olefin-based monomer and a styrene-based monomer used in the present invention is synthesized by conventional methods. There are, for example, methods such as radical polymerization, ion polymerization, and the like. A high-pressure radical polymerization method is described in Japanese Patent Unexamined Publication No. Hei 1-113447. It is disclosed that the monomers are simultaneously or stepwise contacted with

each other and polymerized in the presence of a radical polymerization initiator, a chain transfer agent and, if necessary, an auxiliary agent under conditions of a polymerization pressure of 500-4000 Kg/cm<sup>2</sup> and a polymerization temperature of 50-400°C in a reaction vessel.

[0024] Further, a method of producing the above-mentioned random copolymer using a metallocene catalyst is disclosed in Japanese Patent Unexamined Publication No. Hei 10-273544 and Japanese Patent No. 2,623,070. The metallocene catalyst used in those methods is a metallocene catalyst conventionally used as a single site catalyst, and a metallocene catalyst similar to such a catalyst. In particular, a catalyst comprising a metallocene compound of a transition metal (transition metal compound) and an organic aluminum oxy compound and/or an ionized ionic compound is preferably used. The above Japanese patent publications are incorporated herein by reference.

[0025] The medical tubing of the present invention can be used as a means for transporting a liquid in medical equipment such as an infusion circuit or a blood circuit, and can forcibly transport a liquid by a pump such as infusion pump. One example thereof is shown in Fig. 1. The pump presses the tube from the periphery thereof and transports a drug solution to an objective site while squeezing the tubing. As a result, an accurate flow quantity is transported to a body from an infusion bottle or bag. However, in order to withstand squeezing for a long period of time, it is necessary for the tube to have a sufficient elasticity. The medical tubing in the present invention can provide the required elasticity for use in the equipment. The medical equipment is not limited to the above-mentioned infusion circuit and blood circuit, but includes equipment necessary for various liquid transportation in the medical field.

[0026] The medical tubing of the present invention is formed from a random copolymer comprising olefin-based monomer units and styrene-based monomer units, and does not contain a plasticizer. Therefore, unlike PVC tube containing a plasticizer, the tubing has a characteristic that a plasticizer does not elute from the tubing. Further, the tubing is suitable for administering drugs because the copolymer does not adsorb oil-soluble drugs such as nitroglycerin. The plasticizer referred to herein means a compound added to conventional thermoplastic polymers such as polyvinyl chloride, and which has a possibility of affecting the human body, such as phthalates, e.g., di(2-ethylhexyl) phthalate, di(isodecyl) phthalate, or adipates, e.g., dioctyl adipate.

[0027] The medical tubing of the present invention is obtained by general extrusion molding. If necessary, additives such as antioxidants, lubricants, or the like may be added to the random copolymer. The shape, diameter, length and other parameters of the tube can be selected according to the intended purpose of use, and are not particularly limited.

[0028] The obtained tubing is joined with another part such as a drip chamber used in infusion administration, and then packed in a wrapping and sterilized. Ethylene oxide gas sterilization, γ-ray sterilization or electron ray sterilization can be selected as the sterilization method. The medical tubing of the present invention does not contain butadiene units or the like that require additives when conducting γ-ray or electron ray sterilization. It is therefore considered that γ-ray or electron ray sterilization is possible even in the state of not containing additives such as phosphorus-based antioxidants, e.g., bis(2,6-di-t-butyl-4-methylphenyl)pentaerythritol diphosphite or bis(2,4-di-t-butylphenyl)pentaerythritol diphosphite or the like.

#### Examples

[0029] The present invention is described below in detail using Examples and Comparative Examples. The invention, however, is not limited to these examples.

[0030] In the Examples and Comparative Examples, each test item was measured as follows.

#### Measurement of color tone and transparency:

[0031] After gamma ray irradiation (25 kGy), visually observed.

#### Eluent test by sterilized infusion set standard:

[0032] A tube portion of 10 g was cut in about a 1 cm length, and boiled in 100 ml distilled water for 30 minutes. Distilled water was added to accurately make 100 ml, thereby preparing a test liquid. Simultaneously, only distilled water was boiled for 30 minutes to prepare a blank test liquid.

[0033] <pH> 20 ml of each of the test liquid and blank test liquid was collected. 1.0 g of potassium chloride was dissolved in water to make 1000 ml, and 1.0 ml thereof was added to each of the test liquid and the blank test liquid. pH change of the liquids was measured by a pH measurement method defined in Japanese Pharmacopoeia. When the pH difference was 2.0 or less, it was considered to be acceptable.

[0034] <Heavy metal> 10 ml of a test liquid was collected, and tested according to Method No. 1 of the Heavy Metal Test Method defined in Japanese Pharmacopoeia. For a blank test liquid, 2.0 ml of lead standard liquid was added and tested in the same manner. When color was not dark as compared with the blank test liquid, it was considered to be acceptable.

## EP 1 106 190 A1

[0035] <Potassium permanganate reducing substance> 10 ml of a test liquid was collected in a stoppered triangular flask, 20.0 ml of 0.002 mol/liter potassium permanganate solution and 1 ml of diluted sulfuric acid were added thereto, and the flask was sealed. The flask was shaken and then allowed to stand for 10 minutes, followed by titration with 0.01 mol/liter sodium thiosulfate solution (5 drops of indicator, starch reagent). Separately, the same procedure was conducted using 10 ml of a blank test liquid. When the difference between a test liquid and the blank test liquid in the amount of 0.002 mol/liter potassium permanganate solution consumed was 2.0 ml or less, it was considered to be acceptable.

[0036] <Evaporation residue> 10 ml of a test liquid was evaporated to dryness on a water bath, and the residue was dried at 105°C for 1 hour. If its weight at that time was 1.0 mg or less, it was considered to be acceptable.

### Nitroglycerin adsorption property:

[0037] 60 ml of a nitroglycerin injection (effective component: 50 mg/100 ml, Millisrol injection, manufactured by Nippon Kayaku Co.) was poured into 1 liter of a physiological saline defined in Japanese Pharmacopoeia (manufactured by Otsuka Pharmaceutical Co.), followed by slowly stirring. Sampling was immediately conducted by an injection syringe equipped with an injection needle to prepare a blank sample. A tube of an infusion set was closed with a clamp for controlling flow rate, and a bottle needle of a drip chamber was pierced into the rubber plug of an infusion container. A lower half portion of the drip chamber was filled with the solution by pumping the drip chamber. The clamp for controlling flow rate was gradually released to fill the inside of the tube with the solution, and the tube was attached to an infusion pump FP-2001, manufactured by Nissho Co. Flow rate was set to 36 ml/hr, the clamp for controlling flow rate was opened, the switch was on, and then infusion was initiated. Sampling of the solution which flowed out from the end of the tube was chronologically conducted, and the concentration was measured with high performance liquid chromatography. Infusion was conducted for 180 hours, and sampling was conducted every 5 minutes for the first 60 minutes and every 15 minutes after then.

Column: CAPCELL PAK C18 SG120Å 5 µm φ4.6 mm x 250 mm manufactured by Shiseido Co.

Temperature: 30°C

Mobile phase: methanol:water=11:9

Detector: UV wavelength 210 nm

Flow rate: 0.8 ml/min

[0038] If 90% or less of the concentration was observed as compared with the blank concentration, it was considered that there is adsorption.

### Pump flow rate stability (250 ml/hr, 24 hrs):

[0039] A tube was closed with a clamp for controlling flow rate, and a bottle needle of a drip chamber was pierced into a rubber plug of a container of physiological saline defined in Japanese Pharmacopoeia (manufactured by Otsuka Pharmaceutical Co.). A lower half portion of the drip chamber was filled with the saline by pumping the drip chamber. The clamp for controlling flow rate was gradually released to fill the inside of the tube with the saline, and the tube was attached to an infusion pump FP-2001, manufactured by Nissho Co. Flow rate was set to 250 ml/hr, the clamp for controlling flow rate was opened, the switch was turned on, and infusion was initiated. The amount of physiological saline which flowed out of the top of the tube was immediately received by a measuring cylinder to measure flow rate per minute ( $V_0$ ). After 24 hours, flow rate per minute ( $V_1$ ) was again measured in the same manner. Flow rate change  $(V_1 - V_0 / V_0) \times 100(\%)$  after 24 hours was obtained. It was considered to be acceptable if the change was within  $\pm 15\%$ .

### Tube state after finishing pump infusion:

[0040] After testing the above pump flow rate stability, the surface state, the change in tube diameter and the presence or absence of cracks were observed on the squeezed portion of the tube.

### Example 1

[0041] An ethylene-styrene random copolymer (MFR 9g/10mins, melting point 71°C) constituted of 15mol% styrene

and 85% ethylene was extrusion molded at a melting temperature of 200°C to obtain a tube having an inner diameter of 2.7 mm and an outer diameter of 3.8 mm. Conventional plasticizer was not added.

[0042] The obtained tube was cut into a length of about 1.2 m, and passed through a clamp for controlling flow rate. A drip chamber equipped with a vial spike was connected to one end of the tube, and an intravenous needle, an air trap, an isoprene rubber tubing and a Y-shape duct were connected to the other end of the tube to obtain an infusion set as shown in Fig. 1. After sterilization of the tube with  $\gamma$ -ray irradiation, the color tone and transparency of the tube were measured, and an eluted material test according to the sterilized infusion set standard was conducted. And nitroglycerin adsorption property, pump flow rate stability (250 ml/hr, 24 hours) and tube state after finishing pump infusion were observed. The results obtained are shown in Table 1.

#### Example 2

[0043] A tube was prepared in the same manner as in Example 1 except that an ethylene-styrene random copolymer (MFR 4 g/10mins, melting point 79°C) having a styrene content of 10 mol% and an ethylene content of 90 mol% was used in place of the ethylene-styrene random copolymer (MFR 9 g/10mins, melting point 71°C) having a styrene content of 15 mol% and an ethylene content of 85 mol%, and the same tests were conducted. The results obtained are shown in Table 1.

#### Example 3

[0044] A tube was prepared in the same manner as in Example 1 except that an ethylene-styrene random copolymer (MFR 5 g/10mins, melting point 31°C) having a styrene content of 20 mol% and ethylene content of 80 mol% was used in place of the ethylene-styrene random copolymer (MFR 9 g/10mins, melting point 71°C) having a styrene content of 15 mol% and an ethylene content of 85 mol%, and the same tests were conducted. The results obtained are shown in Table 1.

#### Example 4

[0045] A tube was prepared in the same manner as in Example 1 except that an ethylene-styrene random copolymer (MFR 0.5 g/10mins, melting point 68°C) having a styrene content of 15 mol% and an ethylene content of 85 mol% used in place of the ethylene-styrene random copolymer (MFR 9 g/10mins, melting point 71°C) having a styrene content of 15 mol% and an ethylene content of 85 mol%, and the same tests were conducted. The results obtained are shown in Table 1.

#### Comparative Example 1

[0046] A tube (inner diameter 2.7 mm, outer diameter 3.8 mm, length 120 cm) obtained from polyvinyl chloride containing 35% by weight of di (2-ethylhexyl)phthalate as a plasticizer was subjected to the same tests as in Example 1. The results obtained are shown in Table 2.

#### Comparative Example 2

[0047] A tube (inner diameter 2.7 mm, outer diameter 3.8 mm, length 120 cm) obtained from syndiotactic 1,2-polybutadiene (manufactured by JSR Corporation, RB810, density 0.901 g/cm<sup>3</sup>, melting point 71°C, melt index 3 g/10mins-150°C-2160 g) was subjected to the same tests as in Example 1. The results obtained are shown in Table 2.

#### Comparative Example 3

[0048] A tube (inner diameter 2.7 mm, outer diameter 3.8 mm, length 120 cm) obtained from a mixture of 80% by weight of syndiotactic 1,2-polybutadiene (manufactured by JSR Corporation, RB820, density 0.906 g/cm<sup>3</sup>, melting point 95°C, melt index 3 g/10mins-150°C-2160 g) and 20% by weight of styrene-isoprene-styrene block copolymer (manufactured by JSR corporation, SIS5000P, styrene content 15% by weight, density 0.92 g/cm<sup>3</sup>, MFR 2 g/10mins-200°C-5 kg) was subjected to the same tests as in Example 1. The results obtained are shown in Table 2.

#### Comparative Example 4

[0049] A tube (inner diameter 2.7 mm, outer diameter 3.8 mm, length 120 cm) obtained from a mixed resin of 70% by weight of linear low density polyethylene (manufactured by Dow Chemical Co., PF1140, density 0.895 g/cm<sup>3</sup>) and

# EP 1 106 190 A1

30% by weight of styrene-based elastomer (manufactured by Shell, KRATON G1657, SEBS, styrene content 13% by weight, MFR 8 g/10mins-200°C-5.0 kg) was subjected to the same tests as in Example 1. The results obtained are shown in Table 2.

[Table 1]

Test	Examples			
	1	2	3	4
Color tone, transparency	Colorless, transparent	Colorless, transparent	Colorless, transparent	Colorless, transparent
Eluted substance	Acceptable	Acceptable	Acceptable	Acceptable
Nitroglycerin adsorption property (maximum sorption ratio)	<5%	<5%	<5%	<5%
Pump flow rate stability (250 ml/ after 24 hours)	<10%	<10%	<10%	<10%
Tube state after completion of pump infusion	No abnormality	No abnormality	No abnormality	No abnormality
Total evaluation	o	o	o	o

[Table 2]

Test	Comparative Examples			
	1	2	3	4
Color tone, transparency	Colorless, transparent	Yellowed	Yellowed	Colorless, transparent
Eluted substance	Acceptable	Acceptable	Acceptable	Acceptable
Nitroglycerin adsorption property (maximum sorption ratio)	45%	<5%	<5%	<5%
Pump flow rate stability (250 ml/ after 24 hours)	<10%	<10%	<10%	<10%
Tube state after completion of pump infusion	No No abnormality,	Rough Rough surface	Rough Rough surface	Rough Rough surface
Total evaluation	x	x	x	x

[0050] The tubes of the above Examples 1-4 were colorless and transparent even after  $\gamma$ -ray sterilization was conducted. The results of the eluted substance test by sterilized infusion set standard were acceptable, nitroglycerin adsorption property was a maximum of 5%, pump flow rate variation was within 10%, and no abnormality was observed on the tube surface after finishing pump infusion. On the contrary, in the tube made of polyvinyl chloride containing a plasticizer, nitroglycerin was adsorbed on the tube (Comparative Example 1). In the tube comprising syndiotactic 1,2-polybutadiene containing no antioxidant (Comparative Example 2) and the tube comprising a mixture of syndiotactic 1,2-polybutadiene and styrene-isoprene-styrene block copolymer (Comparative Example 3) were colored yellow after  $\gamma$ -ray sterilization was conducted. Further, the surface was scraped on squeezing with the pump, and many white powdered materials were generated. In the tube comprising a mixture of linear low density polyethylene and styrene-based elastomer (Comparative Example 4), the surface was also scraped on squeezing with the pump and many white

powdered materials were generated.

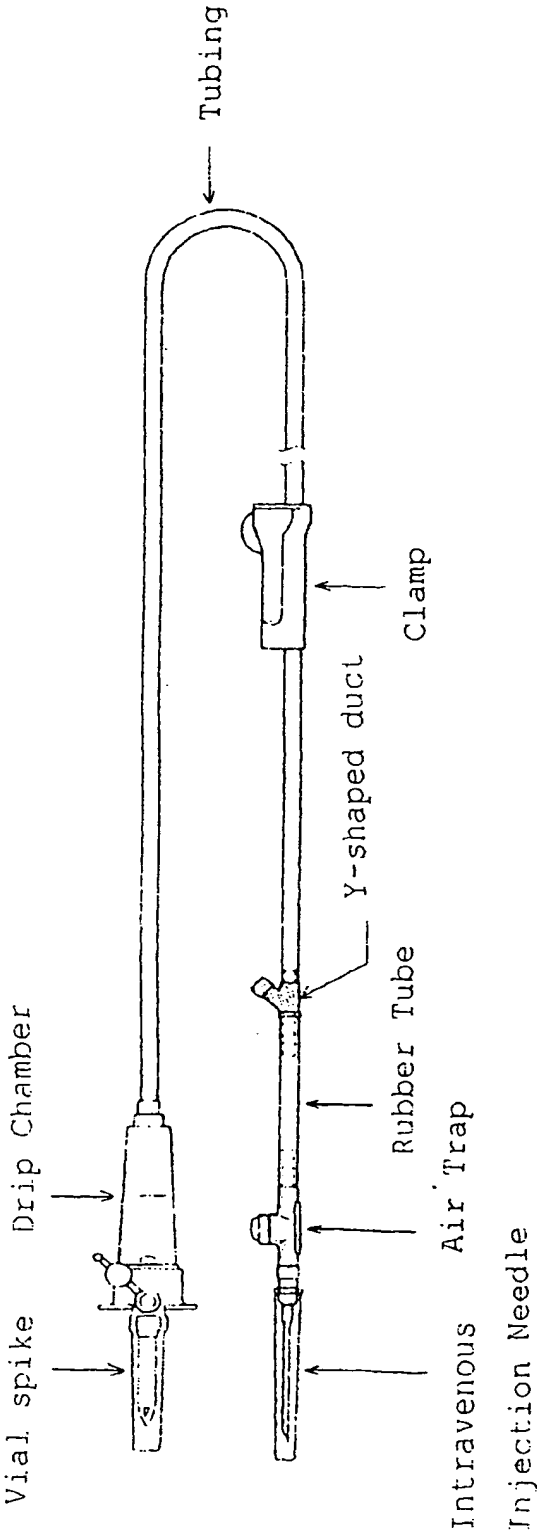
[0051] According to the present invention, a random copolymer of an olefin-based monomer and a styrene-based monomer, not containing chlorine atoms or a plasticizer can provide a medical tubing in which an adsorption of drugs is very small. Further the tubing of the present invention can withstand to squeezing action by an infusion pump, has a possibility of undergoing  $\gamma$ -ray sterilization and has a flexibility necessary for clinical use.

## Claims

1. A medical tubing comprising a tube of a random copolymer consisting of an olefin-based monomer and a styrene-based monomer.
2. The medical tubing as claimed in claim 1, wherein said olefin-based monomer is an  $\alpha$ -olefin.
3. The medical tubing as claimed in claim 2, wherein said  $\alpha$ -olefin is selected from the group consisting of ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 4-methyl-1-pentene, 2-methyl-1-propene, 3-methyl-1-pentene and 5-methyl-1-hexene.
4. The medical tubing as claimed in claim 1, wherein said styrene-based monomer is selected from the group consisting of styrene, p-methylstyrene, t-butylstyrene, vinyl pyridine and  $\alpha$ -methylstyrene.
5. The medical tubing as claimed in claim 1, wherein said random copolymer is further copolymerized with a monomer containing a glycidyl group, amino group, dimethylamino group, hydroxyl group, carboxyl group, ester group, ether group or isocyanate group, or with a maleic anhydride.
6. The medical tubing as claimed in claim 1, wherein said random copolymer comprises 50-95 mol% of the olefin-based monomer and 50-5 mol% of the styrene-based monomer.
7. The medical tubing as claimed in claim 1, wherein said random copolymer comprises 75-95 mol% of the olefin-based monomer and 25-5 mol% of the styrene-based monomer.
8. The medical tubing as claimed in claim 1, wherein said random copolymer comprises 80-90 mol% of the olefin-based monomer and 20-10 mol% of the styrene-based monomer.
9. The medical tubing as claimed in claim 1, wherein said olefin-based monomer is ethylene.
10. The medical tubing as claimed in claim 1, wherein said random copolymer is a random copolymer consisting of 80-90 mol% ethylene and 20-10 mol% styrene.
11. The medical tubing as claimed in claim 1, wherein said random copolymer is a random copolymer consisting of 75-95 mole ethylene and 25-5 mole styrene.
12. The medical tubing as claimed in claim 1, which is a medical tubing used for a liquid carrier in infusion vessel or blood circuit and used in a pump to forcibly convey the liquid.
13. The medical tubing as claimed in claim 1, which is used for an intravenous injection of nitroglycerin.
14. The medical tubing as claimed in claim 1, sterilized with a  $\gamma$ -ray or an electron ray.
15. The medical tubing as claimed in claim 1, wherein a content of a block or blocks of two or more continuous units of the olefin-based monomer or of two or more continuous units of the styrene-based monomer in the random copolymer is 10% or less.



Fig. 1





European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 00 12 6419

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WO 99 45980 A (DENKI KAGAKU KOGYO KK ; ARAI TORU (JP); ODA TAKESHI (JP); OTSU TOSH) 16 September 1999 (1999-09-16) * the whole document *	1-15	A61L29/04 C08L25/08 C08L23/02
L	- & EP 1 062 957 A (DENKI KAGAKU KOGYO KK (JP) ) 27 December 2000 (2000-12-27) ----		
X	DATABASE WPI Section Ch, Week 198538 Derwent Publications Ltd., London, GB; Class A17, AN 1985-234391 XP002163438 & JP 60 153866 A (SUMITOMO CHEM IND KK), 13 August 1985 (1985-08-13) * abstract *	1-4, 12-15	
A	US 5 356 709 A (LO YING-CHENG ET AL) 18 October 1994 (1994-10-18) * abstract *	1	
A	US 5 863 977 A (FISCHER CAROLYN A ET AL) 26 January 1999 (1999-01-26) * claims 1,2 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			A61L C08L C08F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		20 March 2001	Muñoz, M
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

EPOFORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 12 6419

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-03-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9945980 A	16-09-1999	AU 2746599 A	27-09-1999
		EP 1062957 A	27-12-2000
JP 60153866 A	13-08-1985	JP 1837810 C	11-04-1994
		JP 5051305 B	02-08-1993
US 5356709 A	18-10-1994	AT 164086 T	15-04-1998
		AU 661781 B	03-08-1995
		AU 4248693 A	13-12-1993
		BR 9305523 A	18-10-1994
		CA 2112412 A	12-05-1993
		DE 69317508 D	23-04-1998
		DE 69317508 T	05-11-1998
		EP 0597065 A	18-05-1994
		ES 2116450 T	16-07-1998
		JP 7507948 T	07-09-1995
		MX 9302802 A	31-05-1994
		NO 940120 A	13-01-1994
		NZ 252603 A	26-01-1996
		SG 50378 A	20-07-1998
		WO 9323093 A	25-11-1993
US 5863977 A	26-01-1999	US 5459193 A	17-10-1995
		CA 2171542 A	20-04-1995
		DE 69415040 D	14-01-1999
		DE 69415040 T	15-07-1999
		EP 0723571 A	31-07-1996
		JP 9505840 T	10-06-1997
		WO 9510576 A	20-04-1995

EPC FORM P0189

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82